Renewable and Sustainable Energy Reviews 16 (2012) 822–835

Contents lists available at SciVerse ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

The research agenda on social acceptance of distributed generation in smart grids: Renewable as common pool resources

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ARTICLE INFO

Article history:
Received 19 August 2011
Accepted 8 September 2011
Available online 5 October 2011

Keywords:
Smart grid
Distributed generation
Microgrid
Common pool resources
Social acceptance
Community energy
Institutional change

ABSTRACT

The rapid developing literature on 'smart grids' suggests that these will facilitate 'distributed generation' (DG) preferably from renewable sources. However, the current development of smart (micro)grids with substantial amount of DG ("DisGenMiGrids") suffers from a focus on mere 'technology'. Ongoing problems with deployment of renewable energy have shown that implementation is largely determined by broad social acceptance issues. This smart grid development is very important for further renewables deployment, but again there is a tendency to continue the neglect of social determinants.

Most technical studies apply implicit and largely unfounded assumptions about the participation in and contribution of actors to DisGenMiGrid systems. This lack of understanding will have severe consequences: smart grids will not further renewables deployment when there are hardly actors that are willing to become part of them. This review is a first attempt to address the social construction of smart electricity grids. As institutional factors have proved to be the main determinants of acceptance, these will also be crucial for further renewables deployment in micro-grid communities. Elaboration of the institutional character of social acceptance and renewables' innovation calls for an institutional theory approach involving Common Pool Resources management, because these socio-technical systems aim to optimise the exploitation of natural resources. Citizens/consumers and other end-users increasingly have the option to become more self-sufficient by becoming co-producers of electricity.

They may optimise the contribution of DG when they cooperate and insert their renewable energy in a cooperative microgrid with mutual delivery. Moreover, the option to include 'distributed storage' capacity (electric vehicles) in these microgrids, enables an increasing share of renewables deployment. However, all these options should be institutionally opened. This requires much self-governance and flexible overall regulation that allows microgrids.

The research agenda should focus on how such new systems become institutionally embedded, and how they are socially constructed.

Contents

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doi:10.1016/j.rser.2011.09.006

1. Introduction: grid-IQ and renewable energy

From the middle of the 1980s onwards, the major development in energy supply and consumption has been the splintering of central power grids and the simultaneous emergence of regional, decentralised configurations. Traditionally power plants are large centralised units; however, the current trend is towards much smaller as well as geographically widely dispersed power generation units. This type of generation capacity – multiple generating units situated close to energy consumers – is called 'distributed generation' [1]. Distributed generation (DG) is increasingly associated with a more sustainable type of power supply. With atmospheric CO_{2-eq} still increasing rapidly, there is an urgent need for climate change mitigation, and switching to low carbon energy is a primary tool. Applying renewables, in particular in the electricity supply, has become a pressing issue and most renewable energy units must be considered forms of DG. Together with improvements that serve efficiency and reliability, a system with a large amount of DG is considered an environmentally friendly alternative to the traditional power supply system [2].

According to major trends in DG literature, adoption of composite multi-generation systems may yield significant benefits in terms of energy efficiency and reduced carbon emissions, due to the fact that DG combines geographically dispersed decentralised generation from preferably renewable sources. Although today's up-to-date reliable wind turbines usually have a capacity of about 2 MW and more, and the turbines are often sited in wind farm configurations with a number of units, wind power plants are still fairly small compared to the conventional central power plant. Except for large scale hydro-power, most other renewable sources are generated with much smaller facilities, with the standard size PhotoVoltaic panel being smaller than 1 m^2. Hence, these renewable power generating units are sited as decentralised units, often closer to the end-users.

Application of DG, individually distributed generators may also cause reliability problems. The variability in the supply of most renewables is often defined as 'intermittency' that increases unreliability [3]. Reliability of the power systems depends on regulation of energy loads from end-users as well as fine-tuning of energy supply. Both issues require the upgrading of the grid towards a 'smarter grid' [4]. The literature also explores approaches to realising the emerging potential of DG in smart combinations with the associated loads of consumption. For the past decade, the concept of 'microgrids' is posing a serious challenge to the centralisation paradigm of the power grid. Although they are only available in experimental settings today [5] or in developing countries in 'island' settings without a connection to the public grid [6,7], microgrids are likely to play a key role in emerging smart grids. Microgrids can operate as 'islands', but their most prominent common perspective is the integration of DG [5]. Microgrids are being promoted as a model that "will make generation of electricity from resources based close to end users competitive with central generation" [8, p. 413]. This is a growing idea, and currently such 'microgrid' subsystems are being promoted more widely [9–11].

Microgrids have a long history. In fact the first power plants in the late 19th century were microgrids [12,13]. Currently, the microgrid is a cluster of loads of electricity users and microsources that operate as a single controllable system for generating and using power. It encompasses a variety of DG, distributed storage (DS) and a variety of end-use loads [5]. The microgrid enables the production and storage of renewable energy, as well as the exchange of electricity between energy providers and consumers, to take place locally. Such microgrids can combine DG from several energy sources with generating units and storage capacity owned and/or managed by groups of multiple consumers (households and others). They all become small-scale co-providers of energy, reducing their dependence on the public grid [14,15]. The term 'smart grid' generally refers to the larger grid that integrates these microgrids.

According to energy providers, DG produces reliability problems because these generation units are outside of the control of conventional grid operators [3]. Reliability issues concern regulation of energy flows as well as balancing market forces; for both it is essential to install and use 'smart meters' as part of a 'smart grid' [4]. This review addresses the development of combined systems of microgrids with substantial amounts of renewable DG and these systems will be referred to as '*DisGenMiGrids*'. Further on, this paper will review the institutional conditions that favour and hinder the development of such systems.

2. Beyond technology: the importance of social acceptance

2.1. Socio-technical configurations

Though it is a popular concept, the 'smart grid' is still only a buzz word without a precise universal definition. In fact, currently not a single functioning smart grid exists. Despite these ambiguities, there is substantial and accelerated technology driven progress towards developing smart grids [16]. Whereas designing smart grids is fundamentally different from the existing power supply and distribution system, the crucial differences are not only technical. The institutional differences are even more important. The most fundamental changes concern the question how such new energy systems are socially constructed and embedded. All of the actors in power production and consumption would play entirely different roles in a developed smart grid system. New actors would enter the system, and entirely new actors could arise, especially if significant DG from renewable sources is included.

2.1.1. Potential development paths

Today, almost no social scientific knowledge is applied in the development of smart grids. Current technology follows strong but highly questionable assumptions of expected social acceptance of the basic elements of these smart grids. There are two possible paths for development:

(a) policies will be increasingly designed to enhance the autonomy of (local) groups of end-users to further develop their options to apply renewable sources and limit their power supplied by central power plants or
(b) the options for decentralised generation capacity and smart metering will be used for regulating individual consumption behaviour, by increasing the surveillance of domestic consumers by network managers with the aim of regulating demand in line with central policy prescribed levels.

2.1.2. Beyond DSM

Most studies on energy consumption behaviour in households tend to see consumption in terms of individuals who 'respond' to information, price, and social norms in order to reduce peak demand and to shift their loads. References to consumer behaviour in 'smart grid' configurations tend to narrow the focus exclusively on consumer response to price incentives. This basically limits the issue to 'demand side management' (DSM) by providers, emphasising price-based demand response [17, p. 2513]. This myopic focus is still common in policy. It views the smart grid as simply an extension of the existing power grid with an ICT network [18]. Consumers are seen as on-demand receivers of power. In this line of thinking, real-time electricity pricing and demand response – even if it means granting network operators direct control over customer devices – is viewed as furthering the penetration of renewables [19].

This approach seems to fall in line with (b), but the high expectations about acceptance and the real-life changes in consumption patterns as a result of utility-controlled smart meters are rather naïve [20]. Furthermore, it is good to realise that actors principally choose option (b) not to advance renewable energy applications, but rather because it fits existing patterns of thinking, organisation, and power in the energy domain (see Section 5.2). Approach (a) however still requires social science research to support the social foundations of the development of smart grids. If we aim for optimal application of low-carbon generation by exploiting renewable energy sources, this kind of knowledge is essential. Existing knowledge about the deployment of renewables suggests that option (a) provides a much wider scope of possibilities for applying renewables in DG [15].

2.1.3. Institutions

A smart grid is a socio-technical network characterised by the active management of both information and energy flows, in order to control practices of distributed generation, storage, consumption and flexible demand. Following this socio-technical perspective, such infrastructure systems should be seen as combinations of certain technical elements and of elements and characteristics that are needed to make the technology active [21]. These characteristics are '*patterns of social practices and thinking*', which by definition are called '*institutions*'. "Institutions are comprised of regulative, normative and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life" [22, p. 48]. For escaping from carbon in the provision of energy, we may recognise five categories of institutions that may result in lock-ins: [23, p. 318]

- government policies – interventions, legal frameworks, government organisation in departments, ministries and agencies;
- dominant technologies – including standardisation;
- organisational routines and relations;
- industry standards and specialisations;
- societal expectations and preferences

Current energy supply systems are highly institutionalised; they are full of such regulations, norms, and socially and culturally defined patterns of thinking. Unfortunately, they did not develop with a focus on smart grids and are poorly suited to meet the requirements for application of renewables in smart grids.

2.2. Whose 'smart metering'?

Smart grids are needed to fit renewable sources into energy provision networks for two reasons: (a) the energy supply units are generally small and spatially dispersed and (b) their production levels do not follow demand but rather fluctuate with seasonal weather and other natural conditions [4,24]. There is a growing view in policy realms that the operation of systems will be shared between central and distributed generators. Control of distributed generators could be aggregated to form microgrids or "virtual" power plants to facilitate their integration both in the physical system and in the market' [18, p. 18]. However, a smart grid could develop into an even more drastic departure from the current centralised power supply systems. It becomes a network of integrated microgrids that are internally regulated whereby power from different sources is fine-tuned to local supply and demand by consumers of different types [10]. As visible in Fig. 1, at key nodes in the scheme advanced metering infrastructure (sensors, processors and smart appliances) play a crucial role.

Smart meters are the major nodes in the networks of energy flows and information, as they monitor and balance supply, distribution, demand, and storage. Smart metering is a 'no-regret option' [25] for optimisation both from a user/consumer and microgrid point of view as well as from the perspective of the central grid. The intelligent monitoring systems utilised in the smart grid keep

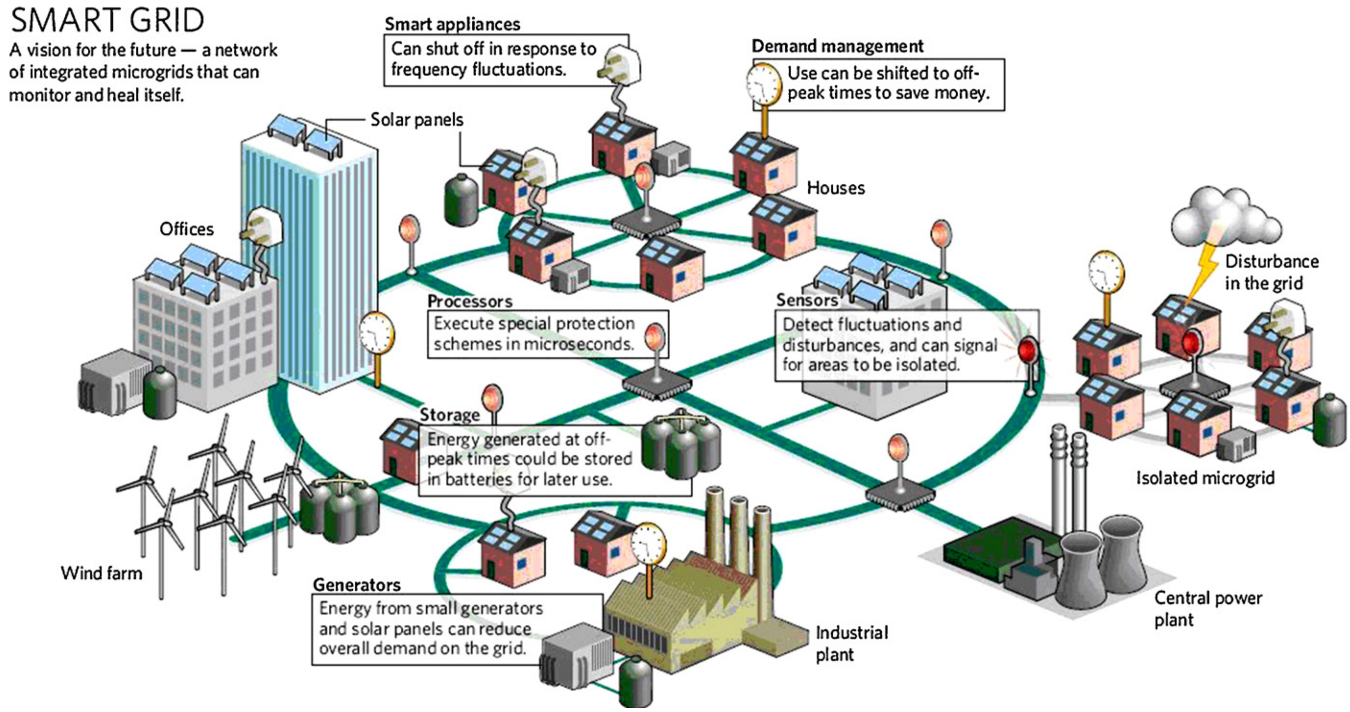

Fig. 1. Smart grid: a "network of integrated microgrids that can monitor and heal itself" [10, p. 570].

track of all energy flows and capacity loads. They consists of a wide range of equipment—covering sensing, measurement (energy, loads, weather, etc.), and control devices.

Smart meters are socio-technical devices that act as hubs for information flows, while serving the needs of domestic energy consumption (programmed off–on switching). Smart meters monitor, display and control [26] energy demand and supply from various sources, taking into account storage capacity and the patterns of the loads of all equipment. This idea runs fully counter to conventional meters that only serve the information requirements of central energy supply companies. In the current institutional frame the advanced metering devices are essentially seen as tools that are operated by the energy supplier or the grid manager [11]. Their primary purpose is to inform different kinds of demand side management (DSM). The crucial social issue, however, is whether to see the smart grid as a means to foster two-way communication, in addition to it providing as operation and control primarily to energy users, who are also most likely producers.

2.3. Consumers: varying and changing characteristics

2.3.1. Consumer assets

Notwithstanding the issue whether smart metering serves the interests of energy supply companies or the energy user (who in the new situation are also energy suppliers), the term 'user' or 'consumer' is ambiguous when considered in energy consumption and production. It can refer to individual households, groups of individuals, an enterprise, or any other kind of organisation [27]. When the users also become producers – as is the case in DG – it is likely that they will also exercise control and management over information as well as energy flows. A smart grid incorporates consumer equipment and behaviour in grid design, operation and communication. These distributed 'assets' must be considered to be the most important characteristic of smart grids [28, p. 68]. These assets provide consumers with control over 'smart appliances' in homes and businesses. They also interconnect energy management systems in 'smart buildings' and enable consumers to better manage energy use and reduce their energy costs and the costs of their partners in the co-operative microgrid community.

2.3.2. Consumer control

After 'distributed assets', 'incorporating distributed energy resources', and 'smart metering', the next important issue is whether "the utility is willing to give the consumer 'limited' "or" 'total' "control of load and generation" [28, p. 74]. Consumers who are managing their own end-use in line with their production capacity, with the help of advanced metering devices, become a very new kind of end-users. Even though having control over one's own consumption and production is essential in microgrids, it is definitely not self-evident. User-control would be nothing less than a complete institutional revolution in power supply. As the developments in the implementation of renewable show, such institutional changes are difficult to achieve [23, p. 322].

The users' control in the microgrid also includes control over the DG units and over 'distributed storage', with different types of devices for demand side management. Such storage capacity is currently neither available nor economically feasible (batteries are still expensive). Flexibility in the demand (e.g., household demand) is nevertheless strongly related to equipment with storage capacity, such as cooling devices and especially electric boilers [29].

2.3.3. V2G storage capacity

The options for local storage are likely to change with the introduction of plug-in electric – or hybrid – vehicles-to-grid (V2G). This development will bring in extra load as well as storage capacity into households [30–32]. Advantages of developing V2G primarily concerns cleaner vehicles, but the impact would only become substantial if these vehicles are loaded by renewables' generated power. The secondary effects are increased stability and reliability of the electric grid, lower electric system costs and, eventually,

inexpensive storage and backup for renewable electricity [33,34]. The benefits are clear:

- Electric vehicles would be charged with electricity generated by renewable sources (conventional electricity does not substantially decrease transport GHG emissions).
- The flexibility in time-of-loading, inherent in the energy storage of a large electric vehicle fleet, offers opportunities to increase the feasibility of smart applications of renewable energy [35,36].

Hence, options for reloading electric vehicles within the domain of microgrid community (e.g., at home) becomes a significant factor in advancing the deployment of renewable energy [26,37]. The consumer view of electric cars is becoming much more positive, but the question is whether this opportunity will be utilised to further the DisGenMiGrid.

2.4. Path dependency

By replacing the conventional consumer-producer relationship with multipronged relationships – the consumer co-producing and supplying for partners in the microgrid as a distributed generator, and vice versa – entirely new relationships emerge. Also other relationships change: consumer-utility, consumer-grid manager, consumer-partners in the microgrid. However, these relationships are not supported by existing institutions in energy provision. Fundamentally, innovation is the introduction not of a new technical system but rather of a socio-technical system (STS). It is a combination of new scientific and technical as well as socio-economic and organisational components. Both components reflect new ideas and concepts on the proffered design of such new systems [38]. The existing patterns of behaviour and organisation are called 'institutions', and these 'rules of the game' [39, p. 4] include 'standard operating procedures' and 'path dependency' [40]. For infrastructure, there it is not only the institutionalised rules that count, there is also an already historically grown physical network in which much of the path-dependent thinking has materialised. This 'hardware' is not easily replaced by new infrastructure. This not only applies for the infrastructure for the energy flows, but also for the other flows in smart-grids, the information and data infrastructure. In information and data network infrastructure this is known as 'installed base' [41]. In power supply the existing infrastructure and routines of metering, data collection, and feedback to the customers may create such lock-ins.

All rules and infrastructure have emerged over time, but usually under different conditions, and the rules and operational standards have not been developed for the requirements of the innovation. Path dependency is often responsible for the unfavourable conditions that forestall the introduction of a new STS. This may easily lead to deadlocks in the development of the new system (known as an institutional lock-ins). Making energy supply systems that can work without adding to the carbon cycle faces all kinds of lock-ins [23]. Many of these situations are due to ineffectiveness of policy within the institutional setting. According to Heiman and Solomon [42] in the US renewable energy generation has to overcome infrastructural barriers – such as lack of storage capacity – but even more important are institutional frameworks such as price distortions, discriminatory transmission system access, and utility rates to covering the additional expense of renewable generation. The roots of such institutional conditions are complex, but they must be analysed in order to find options for levelling out these barriers. Eventually, because these are institutions – patterns of behaviour viewed as 'natural' and perceived as determined by the 'rules of the game' – there are usually only low levels of willingness among key actors to accept required changes in this framework.

3. Acceptance of DisGenMiGrid innovation

3.1. Acceptance of the institutional framework

The willingness to accept key aspects of innovation among actors and markets (enterprises, utilities, authorities, agencies, different publics, civil society organisations, etc.) can be subdivided into two broad segments: (a) acceptance of the creation of the socio-economic conditions needed for implementation and (b) acceptance of all consequences of the innovation. The latter refers to the ways in which implementation will affect and change current practices in society. The decisions that affect implementation of DG in microgrids do not only concern the technologies of PV, wind, smart metering, or electric cars, but especially the institutional setting in which implementation takes place. This setting is framing the acceptance to reserve space for DG units (e.g., on farmland, on rooftops of commercial buildings, on rooftops of private housing, school rooftops, alongside roads, etc.) and the willingness to invest in PV, wind-turbines, or any kind of smart grid assets. The acceptance of PV and other renewables by the actors is determined to a considerable extent by the institutional arrangements of ownership and control of the appliances (e.g., PhotoVoltaics in households) [43]. Generally speaking, the property regimes that regulate all assets in the entire network of DisGenMiGrid are crucial. The ownership of the infrastructure – e.g., generating units, grid, smart meters – are putting in place favourable or unfavourable conditions for optimising the application of the natural resources that renewables offer. The degree of acceptance by key actors and the actors that ultimately should invest in the assets is also determined by the level of trust they have of the institutions and the other actors that guide the transformation of the conventional energy grid into a 'smart grid' [10]. Further below, Section 5.3 outlines a theoretical approach, in which property regimes and mutual trust are key concepts, and that is highly applicable to the socio-technical system of a DisGenMiGrid. First the state of affairs in the significant part of the new STSs, namely the social acceptance of the implementation of renewables, is highlighted.

In technical terms the microgrid can be defined as two networks of electricity producing units and consumption units, as well as a parallel information network with flows of data generated by smart metering devices. The fact that the participants in these networks are social actors has been largely ignored thus far. This ignorance – as experience with social acceptance of renewables has shown – will eventually grow into a huge obstacle: *there will be no smart grid when there are hardly actors that are willing to become part of it*. Why would these actors actually decide to become part of the microgrid? Under which conditions are they willing to install their own generating capacity, and how? Under which conditions are they willing to accept smart metering? Are they willing to change their electricity consumption practices?

Probably the most important question is under what conditions will such willingness be fostered and increased to substantial levels? For example, adjusted patterns of consumption are highly problematic for most users: not only households but also commercial firms may not accept simple demand side management for institutional reasons [20,44]. Are load-patterns adjusted to serve the energy company's wishes, or are they adjusted to better fit the pattern of power generated by renewables of the consumers and their microgrid partners? The emergence of smart microgrids is fully dependent on social co-operation and on the outcomes of behaviour within the new configuration. The literature on smart grids is heavily focused on technology, and consequently does not address issues of social acceptance by all actors involved in the establishment of the smart microgrid. Experiences with the deployment of renewables reveal that ignoring this aspect creates bottlenecks in smart grid development.

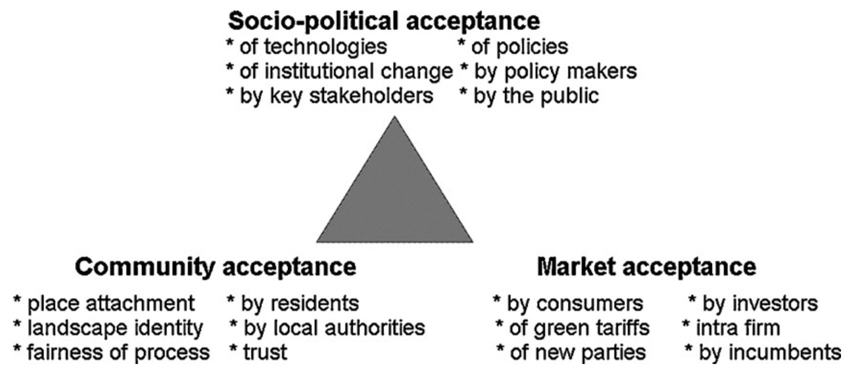

Fig. 2. Three dimensions of social acceptance of renewable energy innovations [54].

Adapted from [53, p. 2684].

3.2. Similarities with renewables

3.2.1. Inadequate policies

The challenges of implementing renewables demonstrate the importance of addressing the social acceptance and adoption of the crucial elements of smart microgrids. The deployment of renewables has progressed remarkably slowly in most countries. The development of a home market has emerged as a key factor in the advancement of the technology and the industry producing renewable energy generating units—wind turbines and PV units alike [45,46]. Most countries have policies and targets for deployment of renewables, but implementation is slow. For example, in the Netherlands none of the policy targets for wind power has ever been met [47,48]. Studies that compared the large differences in applying innovation in the electricity supply among various countries revealed that neither the availability of resources nor energy prices had a defining impact on implementation rates—this credit went to strong institutional factors [49–51]. In fact, the establishment of the necessary infrastructure in environmental governance is often not supported by existing institutions, and this explicitly includes the policy frameworks defined by the same governments [52].

Deployment of renewables faces many problems connected to social acceptance. In the concept of social acceptance of renewable energy innovations three dimensions are distinguished (Fig. 2): (1) socio-political acceptance concerns the acceptance of decisions about the institutional framework; this framework can in turn create favourable conditions or impede the acceptance in the other two dimensions: (2) community acceptance and (3) market acceptance [53].

3.2.2. Implementation framework

Socio-political acceptance helps establish conducive conditions for implementing innovations. It is about the willingness among key stakeholders and policymakers to generate institutional changes and policies that create favourable conditions for new technologies (top of Fig. 2). Among other things this concerns the political and social willingness to price electricity accurately, in particular as related to all externalities of all the alternatives of power generation. As with stagnant deployment of renewables [55,56], fostering socio-political acceptance of the institutional changes needed for developing smart grids could turn out to be the main barrier.

Today's power grids are highly centralised. The emergence of microgrids and DG runs counter to the existing system, which will institutionally impede socio-political acceptance. Regarding innovation, close connections of the sector‘s incumbents with policymakers induces strong inertia and retards the processes of innovation [57]. Advocates of incumbents often claim that renewable sources have failed to deliver on their promises and they emphasise the variability – 'intermittancy' – of the supply of these sources [58]. However, this is not a technological failure relating to their performance, but it is due to the lack of socio-political acceptance to include externalities in electricity prices [56]. As demonstrated by current experience, development is accelerated by the political and economic commitment to the application of instruments that incorporate the cost of renewables into energy tariffs and that fully opens up the grid for all actors interested in investing and operating renewables. Under this class of instruments (usually referred to as feed-in-tariffs), energy consumers pay for the power generated by renewables. Hence, consumers are paying for the kWhs they use, instead of taxpayers subsidizing installed capacity without a reference to actually generated power and use. Pioneering countries like Germany conferred crucial legitimacy and provided the first large industrial experience, allowing for economies of scale and learning through standardisation. The acceptance of such policy principles is furthering renewables implementation, particularly in the first phase of renewables development, as the model of large wind farm schemes generating significant revenues was demonstrated to be viable [59].

3.2.3. Implementation decisions

Beside the socio-political framework, community acceptance and market acceptance concern decisions about the integration of renewable power generation at a particular location and in a community. They also are connected to the actor's (incumbents, new firms, consumers—see Fig. 2) willingness to pay or to invest in wind schemes. During the first decades of the reintroduction of wind power, energy companies, authorities and investors thought that implementation would not face any problems with acceptance. They assumed that high public acceptance would easily translate into implementation.

The research that looked beyond this simple observation – seeking to uncover the details of the conditions that determine the effective support for application of this renewable source (community acceptance) – remained a niche area for almost 20 years [53]. Recently, acceptance issues and their geographical diversity have been widely recognised as crucial for the development of renewable energy. The complex diversity of the social acceptance of DG is also acknowledged among experienced successful developers, but unfortunately within policy realms there are still simplistic ideas about how to implement renewables [60].

What is actually needed to transform the energy supply and demand systems of developed countries into sustainable systems is poorly understood in policy realms. The sustainability is usually defined in terms of wide and necessary diffusion of renewable energy sources and energy efficiency [61]. Although other factors, such as 'stakeholder satisfaction' about other economic and social

needs, sometimes are included in the assessment of sustainability [62, p. 1814], the territorial acceptability of renewables is usually not. This acceptability may be low particularly in cases of 'exogenous and invasive projects that are completely disconnected from the socio-economic and environmental local context' [63, p. 468]. This is a real bottleneck, as the spatial requirements for the generating units and infrastructure that would cover existing levels of consumption are generally largely underestimated [64]. As DG is located close to the users, DisGenMiGrids production should deliver a substantial part of our demand.

4. Community perspective

4.1. Trust

In addition to being physically close, DG increasingly is also at closer 'social distance' when users become the owners/managers of the production units and the microgrid. The actors who decide to integrate their DG units in a cooperative microgrid constitute a community. Correspondingly, community acceptance of infrastructure remains crucial, and whereas community involvement in investment in renewables is favouring community and market acceptance, the inclusion of it in a co-operative microgrid is likely to increase acceptability as well. "Because customer characteristics, particularly the flexibility to cost-effective shift power use, are so varied from one place to the next, we can expect the implementation of smart grid capabilities to be geographically uneven" [65, p. 70]. Any effort to construct infrastructure that is uniform and standardised will face huge acceptance problems.

The literature on the deployment of renewables shows the importance of securing a good fit between the energy schemes and the host communities [66]:

(a) Collaborative decision-making on wind power schemes, which employs effective forms of community involvement, has proven to be crucial for successful deployment.
(b) Successful projects are usually those the community can strongly identify with, as a result of effective involvement and participation in the siting process or due to high community involvement in the management and/or ownership.

Investments and schemes initiated by community outsiders (e.g., energy companies) are much more likely to face resistance by the community. As wind power shows, how decision-making is organised and how social networks at this level are involved in projects strongly shape the possibilities for all community actors to identify with the project (not primarily restricted to residents). The existing body of knowledge on renewable energy innovation shows that for community acceptance essential factors are how well the new system 'fits' into the identity of the community, the perceived fairness of the decision-making process, and the level of mutual 'trust' (see Fig. 2) between community members and the investors and owners of the infrastructure [66,67]. To have solid commitment in implementation of renewable energies, it is essential to create trust to foster the involvement of public and private actors. Planning and decision-making overly focused on formal decisional competencies, and therefore without opportunities for meaningful deliberation, generally fuels conflict [68,69]. Community members must have strong conviction that the new energy system will serve their benefit as well as that the organisation facilitating the process will act in their best interest [70]. "Trusting social relationships support and enable cooperation, communication and commitment such that projects can be developed and technologies installed in ways which are locally appropriate, consensual rather than divisive, and with collective benefits to the fore" [71, p. 2657].

Trust and goodwill must be built intentionally through collaborative processes in planning and energy policymaking consistent with theories on building 'social capital' [72,73]. The institutional framework – e.g., the planning system – should further such collaborative planning and community involvement in the energy system. Adding the microgrid perspective to these observations on implementation of renewables, the socio-political acceptance of adaptation of planning systems to establish planning practices that include early involvement from within the community at the very first stages of development, becomes an urgent issue.

4.2. Identity factors

Implementing a particular energy project is thus, among other things, an ownership and community involvement issue. Community based or community outsider's investments and ownership of the assets of the new development (generating units, smart meters, etc.) is a determinant of acceptance. Acceptance of several DisGenMidGrid characteristics is highly dependent upon the composition of the community and its ambiance. Furthermore, acceptance depends upon how the institutional framework allows communities to shape their own DisGenMiGrid in a way that it optimally corresponds with these identity factors (see Fig. 2, left).

4.2.1. Perceived identity of the location

Attachment to a particular location and the symbolic values of the site to both residents and non-residents play a significant role in shaping people's responses to any proposed changes to their surroundings [74]. A major factor in the emergence of co-operation to manage the common resources in a community is the dominant heritage narrative [75]. For wind and other renewable DG alike, the most important factor for acceptability is related to the perceived qualities of the location, regardless whether these are described in terms of qualities of the 'site', the 'landscape', the 'environment' or other place-related terminology.

'Place attachment' focuses on individual feelings and experiences; therefore, the creation of community benefits by a renewables' developer does not simply increase community acceptability and ease planning consent. The significance of benefits – as interpreted by the community – is correlation to the influence the community has over decision-making about the project [76]. The community planning literature emphasises participation and empowerment, but additional studies on community acceptability have revealed that emotional and cultural connections to place is a very important factor [77,78]. Absence of opportunities for meaningful deliberation in decision-making and neglect of the equity and fairness in the distribution of costs and benefits from locally hosted energy developments usually undermines trust. The culturally and emotionally loaded local identity values cannot easily be compensated by benefits to the community, unless these benefits are also connected to local identity variables. The latter is usually not guaranteed if there is no 'sense of ownership' or a high level of trust in the project developers.

The value of a particular location – primarily landscape characteristics of high value to 'the eye of the local beholder' [79] – may be threatened by the construction of infrastructures, such as wind turbines, PV units on farmland or rooftops or CHP installations. Landscape is a strong determinant of subjective identities, and renewable energy infrastructure such as wind farms [80] or solar plants [81] affects identities. For example, already in the 1980s wind turbines were generally being labelled in terms of 'industrialised landscapes' [82]. This 'industrialisation' is being perceived by the community as a major change in the identity of landscape (as seen in recent cases of near-shore wind power siting) [83–85].

4.2.2. Identity of community members

For all types of DG and smart grid developments it will be important how the geographical identity is interpreted and valued by members of the community. Identity is also a key factor for the determination of the kind of actors that will be granted the opportunity to participate in the investments and the establishment of the DisGenMiGrid. Within a community this obviously concerns the option for households to participate, but equally important are other actors that are important for community identity. For example, schools have fairly large rooftop surfaces available and they could be involved in ownership of wind turbines [86]. Another example is hospitals. They usually have existing operating systems that combine distributed generation options such as PV and co-generation, and they may look at attuning their supply and demand with other community member's demand patterns [87]. Furthermore, identity concerns enterprises like local retail, small industry, offices built for private and public administration, and – especially in rural areas – farming. A special interaction between the perceived identity of the location and social identity factors is found in communities where a substantial number of members derive their income from tourism [88,89].

4.2.3. Identity of load patterns

The essential identity characteristics of communities also concern the specific electricity consumption patterns. Besides the individual member's interest and possibilities to invest in renewables and to use their space to implement DG, the shape of the member's load patterns determines the options for DG. The specifics of their individual patterns are significant identity factors in relation to the patterns of the other participants in the DisGenMiGrid and the supply patterns of the DG units. Furthermore, the identity of the participants determines the flexibility of their consumption patterns. To what extent can these patterns be affected by smart-meter adaptation? The flexibility of households to adapt their energy usage to the variability of wind power is fairly limited [29]. However, the introduction of new types of equipment in combination with smart-meter control devices may generate more flexibility depending on the type of consumer. An important geographic characteristic of a community is local employment rate, responsible for a large part of car use (also including commuting). The impact of electric vehicles on the distribution network will largely be determined by behavioural factors, such as driving patterns, charge timing and vehicle penetration [31].

5. Research agenda: acceptance issues for DisGenMiGrids

5.1. Baseline: renewables as a common good

In this section the focus is on urgent research questions with regards to social acceptance of DisGenMiGrids. From a broad theoretical perspective, based on existing knowledge about the acceptance of deployment of renewables and experiences with natural resources more broadly, key issues are formulated. The base line is that microgrids with their integrated renewable distributed generation capacity should be considered as common property (owned and managed by the members of the microgrid community) that is generating a common good, namely energy based on renewables instead of finite resources that increase carbon in the atmosphere and reduce carbon sink. The overall questions in the research agenda should be: how would such a common good be managed properly? And 'proper management' primarily means how it should be created, because the system is man-made. Furthermore, the maintenance and the optimisation of its application are issues of proper management. There are five conditions for the effective governance of common resources property [90, p. 1908]:

(a) the resources and use of the resources can be monitored, and this information can be verified and understood at relatively low cost;
(b) rates of change in resources, resource-user populations, technology, and economic and social conditions are moderate;
(c) communities maintain frequent face-to-face communication and dense social networks – social capital [72] – that increase the potential for trust and mitigate distrust, and lower the cost of monitoring behaviour and inducing rule compliance;
(d) outsiders can be excluded from using the resource at relatively low cost;
(e) users support effective monitoring and enforcement of rules.

The yield generated by the installed capacity as well as the energy used can be transparently monitored and exchanged (condition 'a' and 'b') with the application of the appropriate smart metering assets, i.e., control by the user/co-producer. However, this development is subject to existing socio-political institutions. Conditions 'c', 'd' and 'e' are about the governance of DisGenMiGrids, their internal regulation as well as the external socio-political acceptance of institutional frameworks that allow such internal regulations.

5.2. Escape from centralised framing

The assets of DG are largely decentralised, and essential agency in technological innovation and development is also widely decentralised [91]. However, the construction of community based microgrids that utilise as many renewable sources as possible is poorly understood in the context where all thinking about the electricity supply is centrally organised. From the viewpoint of early adopters seeking to become co-producers – looking at the conditions for their investments – there is reasonable doubt whether the incumbents (and the regulators) can be trusted [92]. By definition DisGenMiGrids do not have this centralised focus. Beside the technological trends that favoured centralisation and scaling-up in the past – currently the trend is somewhat reversed – what are the problems for renewables and smart grid developments associated with the existing institutional centralisation in power supply? Centralisation, hierarchy and the scale levels of decision-making and ownership are closely connected issues. Unfortunately, beside the significance of these factors for achieving effective management, the core beliefs of key stakeholders about exactly these factors are fundamentally deviating [52,93] in most environmental governance domains, including renewable energy [60].

5.2.1. Tariffs: centralised institutions

The power sector is dominated by institutionalised centralised thinking. In economic theory the recognition of electricity prices as instruments for establishing and extending centralised monopolies has a long history [94]. Although with the onset of DG the monopolies and centralised views are being challenged, there is again a strong path dependency as the integration and stimulation of new DG units is being approached as if the large energy companies are the 'natural' investor in renewables.

One of the implied features of this approach is the emergence of 'green tariff' schemes or 'green power/electricity' programs. This label suggests willingness to invest or to become involved in the establishment of renewables generating capacity can only be expressed by paying a 'green tariff'. The vast number of studies trying to establish estimates of willingness-to-pay (WTP) for renewables tends to focus on these green tariffs [95]. Several studies even suggest that WTP in 'green power' schemes are a proxy for public acceptance of renewables [96,97]. The institutionalised thinking of separated central energy providers versus dispersed individual consumers is so strong that these studies on green power

schemes only look at the generation of funds for renewables by means of energy companies collecting this money. Even when different types of green power schemes are studied, like a difference between voluntary contributions to finance the creation of new generation capacity versus the choice for a higher tariff with a mandatory 100% consumption coverage the basic assumption remains that the energy company should eventually be the final investor in the renewables [98, p. 3–4].

The reality is that 'green power' schemes mainly give energy companies a marketing tool for the diversification of their tariffs, opening opportunities to attract a segment of the market [99]. The actual growth in renewables capacity as a result of these centralised fund raising models remains rather limited. In reality the number of consumers who opt for 'green tariffs' is far below the stated preferences estimates made in the numerous WTP-studies [100]. The effectiveness of 'green power' schemes in increasing the investment by energy companies is also questionable without other policies to encourage such growth [101]. A comparison of the performance of voluntary 'green power' schemes with the achievements of feed-in systems shows a sharp contrast [102]. Whereas 'green power' schemes only generate limited extra investments by energy companies, the feed-in systems that generate rewards for any actor that directly invests in renewables is actually boosting deployment.

These findings suggest that tariff generated funds that flow to distributed co-producers are more effective than centrally generated funds for incumbent power companies. Beside the financial flows, most significant is the fact that feed-in systems grant access to the grid for all, and that they provide financial risk reduction for new investors [103]. Key actors for stimulating investments in renewables' innovations are the professionals in financial institutes who decide on issuing credits for private investors in renewables [104]. All these trends indicate that investment in DG by co-producers has substantially more impact on the growth of renewables than investments by incumbents in the energy sector. DisGenMiGrids would be a step beyond feed-in systems, as they enhance the access to the grid for co-producers and establish options for mutual exchange of energy and storage capacity.

5.2.2. Centralised direction in organisation

The centralised view is institutionally anchored and therefore solid like concrete. This certainly does not apply to power supply only. According to Ostrom, who studied numerous resources management regimes: "Many scholars consider the very concept of organisation to be closely tied to the presence of a central director who has designed a system to operate in a particular way. Consequently, the mechanisms used by organised systems that are not centrally directed are not well understood in many cases" [105, p. 520]. She continues with showing that almost any assumption about the effectiveness of central direction and the possibilities of stimulating good common resources management with uniform and simple incentives remains fully unsupported by empirical data. Research on implementation of renewable energy systems generates similar conclusions regarding incentives and centralised guidance. Many people are even willing to invest in renewables without immediately optimising financial gains [43,54], however preferably 'on their own terms'. As Ostrom puts it for common goods: "Citizens are an important co-producer. If they are treated as unimportant or irrelevant, they reduce their efforts substantially" [106, p. 10].

The issues of social acceptance of renewable energy deployment are reflecting the poor understanding about decentralised organisation as observed by Ostrom [105]). As discussed in Section 4 collaborative planning and community involvement are key for effective implementation by and community support for renewable energy projects. However, even when rooted within the community, implementation is never automatically guaranteed [71]. With regards to the integration of renewable DG in microgrids, one should be aware of the fact that very little is known about how these systems are socially constructed. Hence, more research is necessary regarding the details of the construction of these systems and the optimal utilisation of the potential for renewable DG.

It has been argued that where broader stakeholder interests are sidelined, it is likely that sustainable energy markets will remain largely centralised, inefficient, increasingly costly and exclusive [73]. This is not only applicable to the system of power generation, but also for other sectors that are highly relevant for the development of DisGenMiGrids. For example, the aggregated load of V2G is important for levelling demand and supply unbalances by means of absorption of power ('regulation down') as well as the provision of power ('regulation up') [35,107]. Looking at the transport sector the question arises what kind of infrastructure will be developed for fuelling cars: will the storage techniques in cars fully support recharging at home or at the working place? Or will they be shaped to fit to large on-the-road recharging stations? The first option is favourable to regulation up and down to enhance the establishment and feasibility of DiGenMiGrids. However, this may well stand in contrast to the interest of many incumbents in transport energy provision—for example, fuel companies, fuelling stations, associated car dealers, tax collecting authorities. These actors may opt to safeguard their institutionally founded gatekeeper position in the energy supply by choosing compatible solutions, for example centralised loading stations, similar to current gasoline stations. The strategic choices that will be made about this infrastructure – the creation of the 'installed base' (see Section 2.4) – will narrow the path for utilising V2G for the enhancement of renewable energy generation in microgrids.

5.3. Optimal use of a common resource

5.3.1. Characteristics

Elaborating on the social construction of DisGenMiGrids, some significant characteristics of such systems emerge:

a. natural resources – renewables;
b. scarcity – in particular the space needed to locate the power generating units and the time patterns of the availability of the resources;
c. co-production of a common good – electricity for anyone participating in the microgrid; avoidance of environmental impact of conventional power generation;
d. self-organisation – making a community around the microgrid; using community social capital to build a microgrid;
e. large diversity in optimal designs of the socio-technical systems – with regard to the natural conditions (landscape, climate, resources) as well as societally defined identity factors.

5.3.2. Common pool resources

The options for achieving optimal use of renewable energy in a socio-technical system like a DisGenMiGrid can be viewed as a governance issue related to sustainable management of a common pool resource (CPR) [90]. Hence, the knowledge of managing CPRs by 'polycentric adaptive governance' comes to the fore as a fruitful approach to studying the management of renewable energies. Fully in line with social acceptance and innovation theories on renewables implementation, CPR theory focuses on institutions [108]. Furthermore, it combines the starting point of a socio-technical system – like nature-based common pools are socio-ecological systems – with a rational choice-based theoretical foundation [109]. This approach to taking decisions regarding investment and participation is also highly applicable to smart microgrids [110].

5.3.3. Access and co-production

A CPR is "a natural or man-made resource in which it is difficult to exclude or limit users once a resource is provided, and one person's consumption of the resource units makes those units unavailable to others" [105, p. 497]. DisGenMiGrids are man-made systems, but unlike conventional power supply their primary objective is to harvest the natural resources of renewable energies through co-production. In CPR theory co-production of the common good is considered an essential element of a good governance regime [106]. Once users are connected to the microgrid as co-producers they cannot be excluded from consumption. This means they have access to the resource, but it is regulated access. Obviously, every kWh used by one consumer is not available to others, and as part of the rules agreed upon in the system, consumption may be bounded to a regime of a demand management scheme. However, in contrast with usual DSM systems that suffer from low acceptance and limited achievements [20] this time it is a regime that is agreed upon by the members of the microgrid community, tailored to their identity, and monitored and managed by smart meter devices controlled by the users. Access to the resources is also limited because of spatial requirements. All space available for siting power generating and transporting infrastructure is limited because of property rights (rooftops, land, public space) and resource-rights [111].

5.3.4. Diversity and flexibility

Due to the substantial variety in Microgrids – both in their social and technical dimensions – they require adaptive and flexible governance. Complex adaptive systems are composed of interacting agents, which may adapt the performance of their system by changing their rules based on experience and changing conditions [105, p. 521]. DisGenMiGrid can become such an adaptive resource governance system with high level of self-organisation, as it will most likely exist on a small, dense group of contiguous geographic sites that exchange energy (and possibly even diverging low voltage power and heat [8]). Such a group is built upon the willingness of several end-users to become co-producers, because they see merit in co-operating in production and consumption of power. The general smart grid becomes a complex adaptive system that aggregates several widely varying subsystems. The subsystems – microgrids with installed DG capacity, which 'monitor and heal themselves' [10] – must be 'adaptive' because they must be able to fit within the local setting (identity factors) and to adapt to changing conditions. They should be able to apply different and flexible rules within their system for optimal functioning. The options for these systems to establish their own adaptive regimes are very limited in today's institutionally centralised and inflexible power supply systems. This social acceptance issue will probably be the main barrier.

The character of 'adaptive governance' in such subsystems is central to innovation. First of all the governance of the systems starts with incorporating essential identity factors of the community and its members. Just a simple example: the different identities in urban or rural settings [112] will largely determine the options for constructing and governing DisGenMiGrids. But the adaptive capacity of the socio-technical system and the community also refers to their ability to incorporate learning experiences by implementing information about other systems that are applying new technologies and the lessons learned.

5.4. Research topics

The basic assumption is that a DisGenMiGrid is a socio-technical system founded on organisational principles that are similar to other common pool resources. The questions that arise can be formulated in line with the institutional conditions that are considered key to adaptive governance for sustainable CPR management. I have categorised these issues based on review of the literature on adaptive resources governance and review about the factors that are identified to cause failures in such systems [90,105,106,109]. There are many significant factors, but no standard solutions are available. CPR management is complex because it encompasses a wide variety of vulnerable systems with many different property regimes. There are private property regimes, government controlled resources, and also local-level management regimes, but there is no general rule for their effectiveness [113]. Much more research is needed on natural resources, which makes it even more urgent to start research on a manmade system like the DisGenMiGrid.

5.4.1. System boundaries

First of all, the systems should be defined. What is the appropriate size and what are the boundaries – microgrid versus public grid – of a good working microgrid based on renewables? To define the system, information about the characteristics and the conditions of the environment in which a DisGenMiGrid can be established should be available. Dietz et al. [90, p. 1910] call this the 'necessary information' needed to devise rules that are congruent with the 'ecological conditions'. Translated to DisGenMiGrid this is information about all significant identity factors of the community in which the renewables can be installed and where the generated power can be directly used within the same community.

As a first step, the meaning of the understanding of "community" should be defined. With regards energy and climate change issues more broadly, Walker [114] distinguishes several meanings for the concept of "community": community as '*identity*', as an *actor*, as identification of a *scale*, identifying a *network*, and even as describing a *process*. The system definitions should make clear what elements are essential for studying micro-grid communities.

The definition of system boundaries is particularly important for dealing with the interests within a community and with potential conflicts of those interests. Since DisGenMiGrids do not yet exist, we hardly know anything about appropriate system boundaries, and therefore all demonstration projects and experimental trials that apply elements of such systems should be scholarly monitored and evaluated. Unfortunately, as is the history of renewable energy implementation shows, this is usually focused on the technology [5] but hardly on the organisation (who is participating and how, who is deciding on participation rules, etc. [7]) and the institutional arrangements surrounding these projects.

5.4.2. Ownership

Another important research topic concerns ownership and control of the various assets of distributed generation units as well as the microgrid. All studies of CPRs lead to the conclusion that there is no single broad type of ownership (government, private or community) that uniformly supports good resource management [90,113]. Because of the wide variety in identity of the systems, for every new case it should be possible to design appropriate, context specific, adaptive ownership constructions—collective, private, public or fine-tuned property combinations. Ownership may also be separated from management. This might be done by specialised actors, for example, newly created ESCOs (energy service companies). The research should focus on new experimental types of managing generating capacity and grids, particularly those that incorporate the co-production of power supply. Furthermore, the issue is how these management models can be optimally adapted to the identity of the community, considering all dimensions of those identities (see Section 4.2). The experience with common pool resources shows that there is no panacea, no simple, universal solution for good management [115]. Because of large geographic diversity among communities, it is not likely that it is possible to find a panacea for managing DisGenMiGrids.

The first issue is to what extent it is essential that ownership and management constructions are grounded in exercising control over the most important assets of the DisGenMiGrid within the community. A second equally important issue is where and how to limit external control over the microgrid community. This is an urgent question, as most existing power supply systems have a path-dependent central control bias in their organisation, in the 'installed base' and in their thinking. This is of course a question of far-reaching institutional change, and the main question is how to generate socio-political acceptance of such changes within existing centralised institutional settings.

5.4.3. Access rules

Obviously, the essential characteristic of renewables is that the resource is free. This is clearly apparent for solar radiation and wind, but for small hydro and geothermal energy the free access to the source is less evident. The space needed for infrastructure to collect the resource and to convert it to applicable energy is scarce. This space is divided in private, collective and public space—all of which are limited.

A further limitation – and a need for internal regulation for resource access – concerns the spatial requirements linked to resource rights [111]. The flow of energy (solar radiation, wind, water flows) should not be interrupted, but this implies some limitation on design of harnessing infrastructure. Hence, when power generating units are constructed they create scarcity because they require regulation of construction, and vegetation. Furthermore, the impact of all infrastructure goes beyond direct ownership and uninterrupted energy flows. It mainly concerns viewsheds, sound contours, wildlife—essentially covering all landscape impact, including economic value, such as tourism or value as cultural heritage site [116]. Siting such infrastructure should be done according to collective arrangements that can protect place identity characteristics. Adaptive styles of governance of such values, i.e., collaborative planning instead of top–down inflexible planning based on general standards (Section 4.1), has already shown to be important for implementation of renewables. Nevertheless, these identity factors all limit the construction of power generating capacity, and consequently they create scarcity of the resource.

5.4.4. Compliance rules

What can be the architecture of internal regulation within the system of a DisGenMigrid? What general institutions, in particular legal regulation and organisation in power supply, should be changed in order to make this architecture possible? General regulation should allow for flexibility and adaptive governance at the system level. These rules concern terms of connection to the microgrid, rates of exchange of energy generated and consumed, externalities of energy production, siting issues, as well as fraud and other issues. The required accountability within the system and adequate monitoring should be served with well-designed compliance rules [90, p. 1910]. Here the definition of smart metering is essential, as it should leave options open for optimisation of mutual exchanges of supplied and consumed power. There should be options for using the data for optimisation of local co-production, storage and consumption on different levels, within the system of each member as well as in the exchange between the members. The smart meters can be designed differently at different levels, up to the connection with the public grid.

Numerous issues need to be addressed by creating rules:

- access regulations to resources and consumption for all different kind of actors;
- the right to deliver to the microgrid – which implies to neighbouring consumers – without interference from central agencies, energy supply companies or public grid managers;
- simple and easy rules for joining a microgrid community;
- plug-and-play options for energy production and metering devices are needed [43]. This requires standardisation for such equipment at larger scales, but it also requires regulation that does not interfere with installation within the microgrid;
- opportunities to adapt the system, the technology as well as the internal governance to the identity of the community and changing conditions.

A fundamental question is whether the microgrid is seen as one actor exchanging power with the public grid, or as a set of individual consumers in the centralised supply frame. Internal monitoring will support an internal tariff system, the use of storage capacity and the adaptation of individual demand, but how can this be achieved without interference from centralised institutions? What about the power generated by one participant that is subsequently used by another? Current regulation in most countries does not allow direct delivery of power–there is an obligation to use the public grid. Ironically, these rules are showing the path dependency of the existing power supply system, as the main argument for this monopoly is consumer protection [13]. And what about taxation of energy flows? Can the DisGenMiGrid be qualified as one tax-paying entity, or will states claim that all power flows within the microgrid be monitored and taxed? The latter would drastically change the conditions (i.e., feasibility of mutual power supply and limitation of smart meter control) for optimisation of the microgrid and the generation of renewable DG.

6. Concluding remarks

What are the social foundations of smart grids? They consist of decentralised socio-technical networks that underpin the electricity consumption of groups of consumers/end-users who are increasingly becoming autonomous. These socio-technical networks form a community that exhibits high levels of interaction and integration between the actors, while the social construction of smart metering is a key factor in determining the character of the smart grid. Most existing institutions, which are designed to support the centralised power supply system, will prove to be unfit for creating, operating, and managing microgrids within an integrated smart grid. This will likely impede the deployment of distributed generation, in particular renewable energy. Hence, such centralised institutions should be completely reshaped, as the deployment of renewables is a key to a low carbon energy provision.

Critical to the development of decentralised renewable power generation is the possibility to optimise within the community on which the microgrid is based. Establishing such systems requires institutions that support mutual trust and trust in the governance frameworks [117] (see Section 4.1). Although the introduction of DisGenMiGrids has its specific system characteristics, the governance issue of how to escape from simplistic increasingly ineffective centralised institutions can be recognised more broadly. In fact the governance of emerging smart grids may become a textbook example of the new kind of environmental governance that is needed for escaping from the 'carbon lock-in' [23]. Such governance should move beyond existing hierarchies and beyond the ways of current separation of levels of decision-making about infrastructure and networks [118]. The highly related ways of thinking about centralisation, hierarchy, and scales of decision making must be reconsidered in most domains of environmental governance, but they are particularly crucial in managing renewables as a common good.

Looking at existing centralised power supply systems, it can be hypothesised that policies will tend to adopt a frame of generic, undifferentiated approach to promoting renewables. This creates the risk of standardising the initiatives, with frames that particularly frustrate the initiatives of the 'early adopters' who are essential 'prime movers' [119]. The problem is that 'smart grids' have become a buzz word, also embraced in policy circles and are considered an answer to many problems regarding increasing energy consumption, peak loads and renewables implementation. However, the proper view on the institutional changes that are needed to turn these promises into reality is lacking. On the one hand, there are large expectations about smart grids, and on the other there remains a complete lack of understanding of the need for institutional change required to establish them. Unrealistic expectations, especially the belief that smart grid programs will reduce power bills [65], will eventually lead to disappointment and will create distrust.

According to CPR theory good governance is not only adaptive, but all decision-making is also highly polycentric, which refers to the many different centres of decision-making at different scales. By definition, the most essential dimensions of DisGenMiGrids should be decided upon in each microgrid community, but on larger scales generic rules should be created that allow diversity and further the creation of such communities. 'Polycentric systems tend to enhance innovation, learning, adaptation, trustworthiness, levels of cooperation of participants, and achievement of more effective, equitable, and sustainable outcomes at multiple scales' [120, p. 552]. At the start of the drafting of policies to develop and apply renewable energy, general social acceptance issues were taken for granted, lacked recognition and consequently were largely neglected [53]. Due to this neglect, their development has been fairly slow. Similar neglect of the factors that determine the social construction of distributed generation with microgrid configurations will also slow down such developments. Ultimately the danger is that it will impede the application of the most promising solutions for smart grid development.

Acknowledgements

This review builds upon two previous papers: (1) presented at the conference "Visions and strategies to address sustainable energy and climate change", 25–26 November 2010, University of Oslo, Norway; (2) a lecture "Distributed generation of sustainable energy as a common pool resource: Social acceptance in rural settings of smart (micro-)grid configurations", 4 July 2010. Paper to be published in B. Frantál and S. Martinat (forthcoming 2012): New Rural Spaces: Conflicts, Opportunities and Challenges. Czech Academy of Sciences, Brno.

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